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Investigation of Environmental Change Pattern in Japan

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UTILIZATION OF LANDSAT-2 DATA FOR FISHERIES

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1. Introduction

It has been established that MSS data obtained by LANDSAT-2 provide us with great store of information about marine environments and their changes (Cf. Final Reports of such co-investigators as Drs. H. OCHIAI, D. SHOJI and K. WATANABE). From the viewpoint of fisheries, such information about marine environments are indispensable for fortelling fishing condition and for management of fisheries resources. Among diverse information, those involved in environmental control, such as eutrophication and pollution of the sea, are very important in relation to vicissitude of abundance and distribution of fish populations.

This report elucidates how MSS data is utilizable for fisheries on the basis of analysis of some imageries of MSS-4 and MSS-5 that covered a part of the Pacific coast of Japan.

2. Techniques

The imageries of MSS used were black and white photographies that covered the sea area extending from the Enshu-Nada to Ise Bay on September 11, 1975, and around the Kanto District and the Izu Islands on July 29, 1976.

The sea truth is consisted of oceanographic observations in the similar time-

space coverage of LNDSAT-2 as well as data on distribution of fishing grounds and catch statistics for the same area and season.

3. Accomplishment

3.1. *Shirasu* fishery:

The neritic waters in the Enshu-Nada is known to be the biggest fishing ground of *shirasu*. The word *shirasu* designates a growth stage of Clupeoid fishes at the later period of postlarval stage with total length about 20 mm to 40 mm. The *shirasu* catch from the Enshu-Nada in the summer season is mostly composed of that of anchovy, *Engraulis japonica*. September 1975 (of which MSS-4 data were available) corresponds to one of the peaks of the *shirasu* catch, which was never taken so much in the same month of the previous year (Fig. 1). A heavy spawning of anchovy took place in this sea area in July 1975 (Fig. 2). Hatched larvae from this spawning were abundantly caught by *shirasu* fishery one or two months later (August to September).

The spawning and nursing areas of anchovy are usually located in the neritic waters lying coastwards the Kuroshio Current. They are easily fluctuant time and space in corrresponding to the shift of the axis of the Kuroshio as well as fall and rise of neritic water. The center of spawning area of anchovy does not coincide with the major fishing ground of *shirasu* (Figs. 2 & 3). In some years there are heavy patches of *shirasu* in the neritic waters of the Enshu-Nada, while population densities of *shirasu* are very low in the other years.

In July 1975, the Kuroshio water made a pronounced intrusion into the coastal area of the Enshu-Nada because the meander of the Kuroshio caused a formation of a cold water mass offshore (Fig. 3). It is assumed that this sea condition resulted in a belt-like concentration of *shirasu* in parallel to the coastal line and thus in good catches of *shirasu* this season. This oceanographic condition was well shown in MSS-4 imagery for September 11, 1975 (Plate I).

There is a tendency that *shirasu* are frequently concentrated in a low saline area where receives a river efflux. The imagery of MSS-4 shows that there was an eastward dispersion of the effluent from the River Tenryu. This could be interpreted that an eastward current was predominant in the neritic waters then and there. As westward currents have been more frequent in usual years in this particular sea area, the existence of an eastward current was very peculiar. This might be caused by the above-mentioned oceanographical condition and resulted in a reverse pattern in shifting of *shirasu* fishing grounds in the Enshu-Nada.

Commercially exploitable stocks of *shirasu* are supplied from the spawning site towards Ise Bay-Mikawa Bay and both East and West grounds off the mouth of the River Tenryu (Figs. 2 & 3). The *shirasu* catches from either the East or the West fishing grounds off the mouth of the River Tenryu were poor in the very day of September 11, 1975. But, 3 days later (September 14), the good catch was first taken in the West ground (landed at Maisaka) and on the following day (September 15) in the East ground (landed at Fukude)(Fig. 4).

The *shirasu* catches show pronounced fluctuation day after day. Ups and downs of catch depend upon the fact whether the fishing ground is covered by neritic water with low transparency but with abundant *shirasu* population or it is predominated by offshore water with high transparency carrying poor fish population. The behavior of coastal water mass gives an important influence upon fishing condition. Therefore, MSS data which supply us with distribution pattern of water masses are very useful and important for forecasting *shirasu* fishing conditions.

3.2. Sardine fishery:

Sardine, *Sardinops melanosticta*, is caught in the neighborhood of Kanto District in the late July, while the major part of the stock has gone up to the coast of Hokkaido as the north-going feeding shoals (Fig. 5). The time-space changes in location of fishing grounds in this sea area are strongly influenced

by the coastward movement of the Kuroshio as well as southern intrusion of the Oyashio water.

Fig. 5 demonstrates locations of two sardine fishing grounds off Kanto District for a week from July 28 to August 2, 1976 (MSS imagery used for comparison was for July 29, 1976). One of fishing grounds was found shifted more northwardly than the previous week as fish schools were pressed towards the coast of the Kujukurihama Beach by coastward movement of the Kuroshio. Another fish school seems to be held back from north-going migration by a coastward intrusion of a warm water tongue towards the coast of the Kashima-Nada. MSS-5 imagery clearly showed locations of coastal water and Kuroshio water masses (Plates II & III).

If imageries are avaialble successively for the major fishing season (December to May), they are most important information for foretelling distribution of fishing grounds.

3.3. Translocation and recruitment of fish eggs and larvae:

General speaking, eggs and larvae of many species of neritic and offshore migratory fish are translocated by the Kuroshio to the northeastern direction while they are growing. They are sometimes absorbed either in the marginal portion of the Kuroshio or in the neritic water mass in corresponding to fall and rise of these two different water masses. MSS data such as eddy-like structure in the Izu Island area (Plate III) and vortex pattern in the Kumano-Nada (Cf. Final Report by Dr. D. SHOJI) give us a clue for elucidation of mechanisms of transportation and distribution of fish eggs and larvae.

Major spawning grounds for sardine and common mackerel, *Scomber japonicus*, are located in the waters around the Izu Islands. If we can know distribution and movement of water masses in an extensive geographical coverage, we can make a rough estimate on distributional and drift areas of fish eggs and larvae. Such an information is one of the most important basis for forecasting the recritment and consequently for managing the fisheries resources.

3.4. Red tide:

Fig. 6 shows distribution of water color of Atsumi Bay in September 1975 on the basis of the red tide investigation conducted by Aichi Prefectural Fisheries Experimental Station. The report from the same station said that this red tide was ceased by September 10. However, according to MSS-4 imagery for September 11 (Plate IV), it made clear that the red tide was not ceased but only shifted to offshore from the inner portion of the Bay that had covered by Aichi PFES investigation. In connection with this, mass mortality of fish was reported in the area of "pale blue" in Fig. 6.

For identification of red tide, the reader may refer the report by Dr. H. OCHIAI (this final report). If MSS data are avaialble successively for a short period, they are very helpful for elucidating the mechanism of red tide and for forecasting the occurrence of red tide that will give a destructive effect on fisheries.

4. Significant Results

MSS data provide us with extensive and simultaneous information about marine environmental conditions, such as the shift of the Kuroshio, fall and rise of coastal water mass, distribution of water masses, locations of vortex and current rips, excahnges of water between embayment and open ocean, effluent of rivers, fertility of plankton, red tide, pollution etc. These information are all useful for fisheries as will be briefed below:

4.1. Forecast of fishing conditions:

Distribution and abundance of neritic and offshore migratory fish including sardine, anchovy, mackerels, saury, skipjack, tunas and squids are closely related to biotic and abiotic conditions of environment. It is axiomatic that environmental information obtained by LANDSAT improved accuracy of forecasting fishing conditions of these fishes.

4.2. Management of fisheries resources:

From the change pattern of environment, distribution and drift patterns of fish eggs and larvae will be estimated. This gives an estimate of abundance of recruitment which is the basis of management of fisheries resources.

4.3. Identification of marine pollution and eutrophication:

Data concerning exchanges of water between neritic area or embayment and oceanic area are helpful in judgement of purifying capability of sea water.

Extensive information of occurrences of red tide and oil pollution as well as other environmental worsening help to take measure against fisheries destruction.

5. Problems

(1) Utilizable data were few as many scenes available were very cloudy.

(2) Data in short-term intervals, such as daily or weekly, were not availble for judgement of oceanographical changes in relation to fisheries.

(3) If detection and measurement of seasonal changes of such biotic parameters as fertility of plankton and chrolophyll are sucessfully made in future, these information will be of great use for identifying temporal and spacial scales and changes of eutrophication and pollution as well as for mangement of fishing resources and fishing activities.

(4) Data of sea surface water temperature is indispensable.

6. Conclusions

The extensive and simultaneous coverages of MSS data obtained by LNDSAT are never incomparable with hydrographic observations made by sea-going vessels. MSS data help to make great progress in researches and methodologies concerning forecast of fishing condition, management of fisheries and identification of pollution by collating with information obtained by research ship, fishing fleet and aircraft.

To make MSS data utilizable for fisheries, development of the technique of reading environmental change pattern must be preceded. It is desirable that observation data with intervals not longer than one week (if possible, daily) could be obtainable at real time in future.

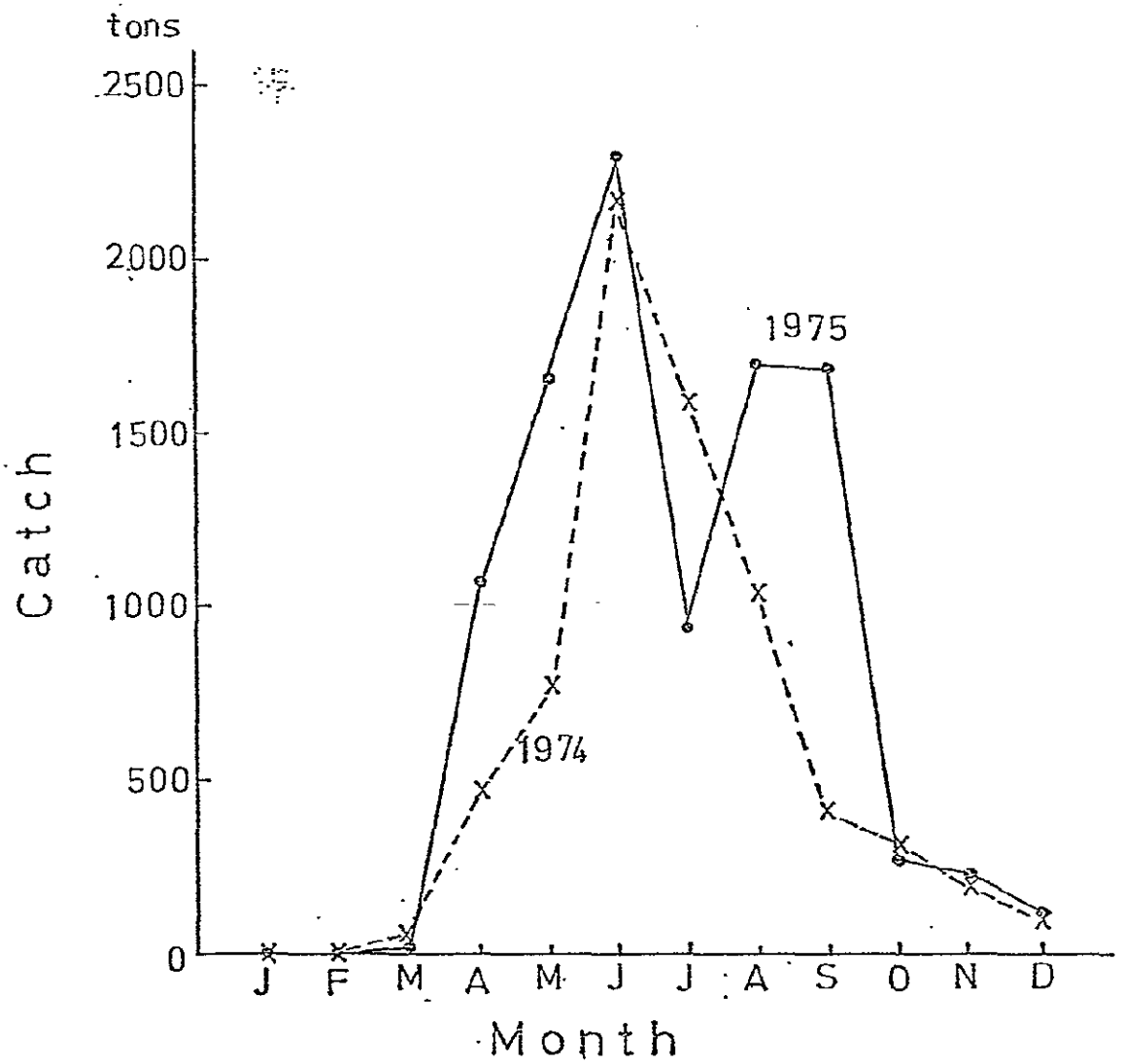

Figure 1. Monthly *shirasu* catch from the Enshu-Nada and neighborhood (statistics of Shizuoka Prefecture) 1974 and 1975

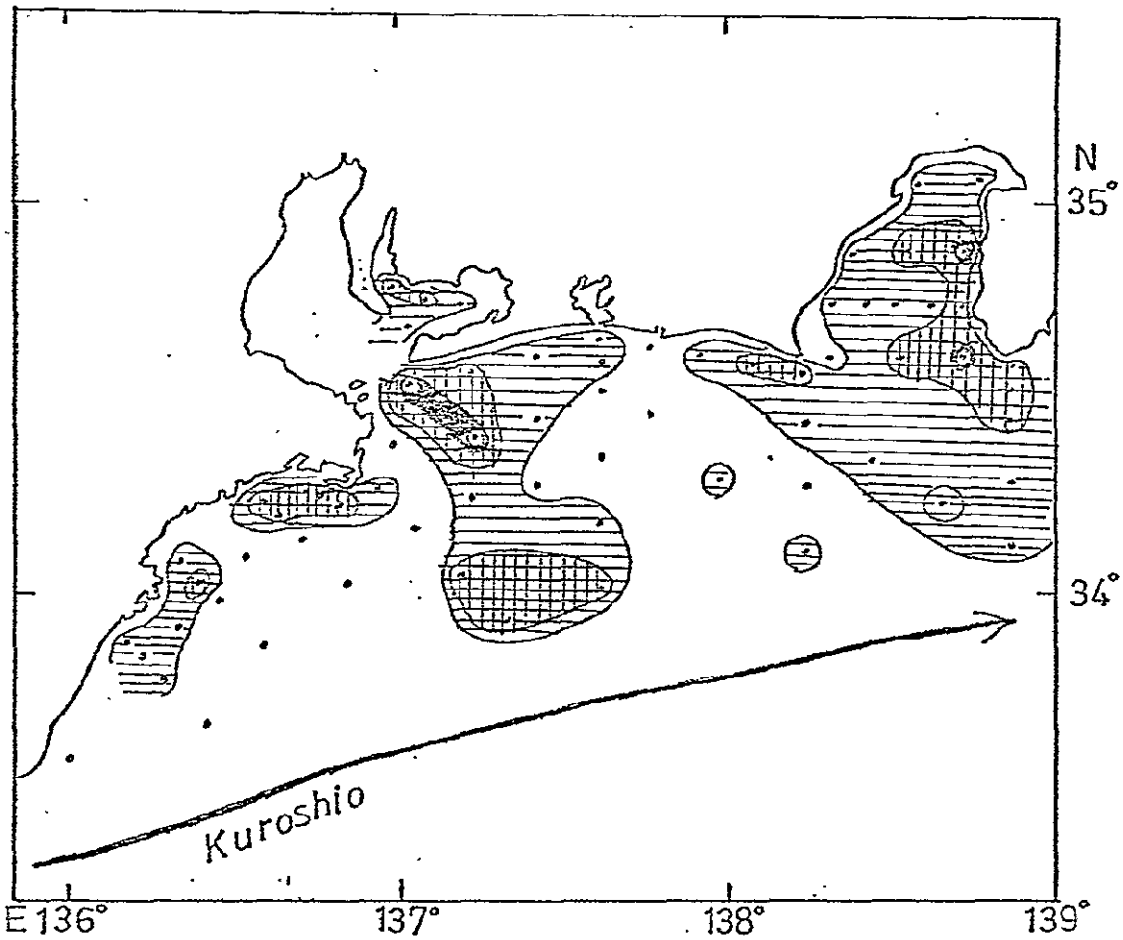

Figure 2. Density distribution of anchovy egg in July 1975 (After data of Shizuoka, Aichi and Mie Prefectural Fisheries Experimental Stations)

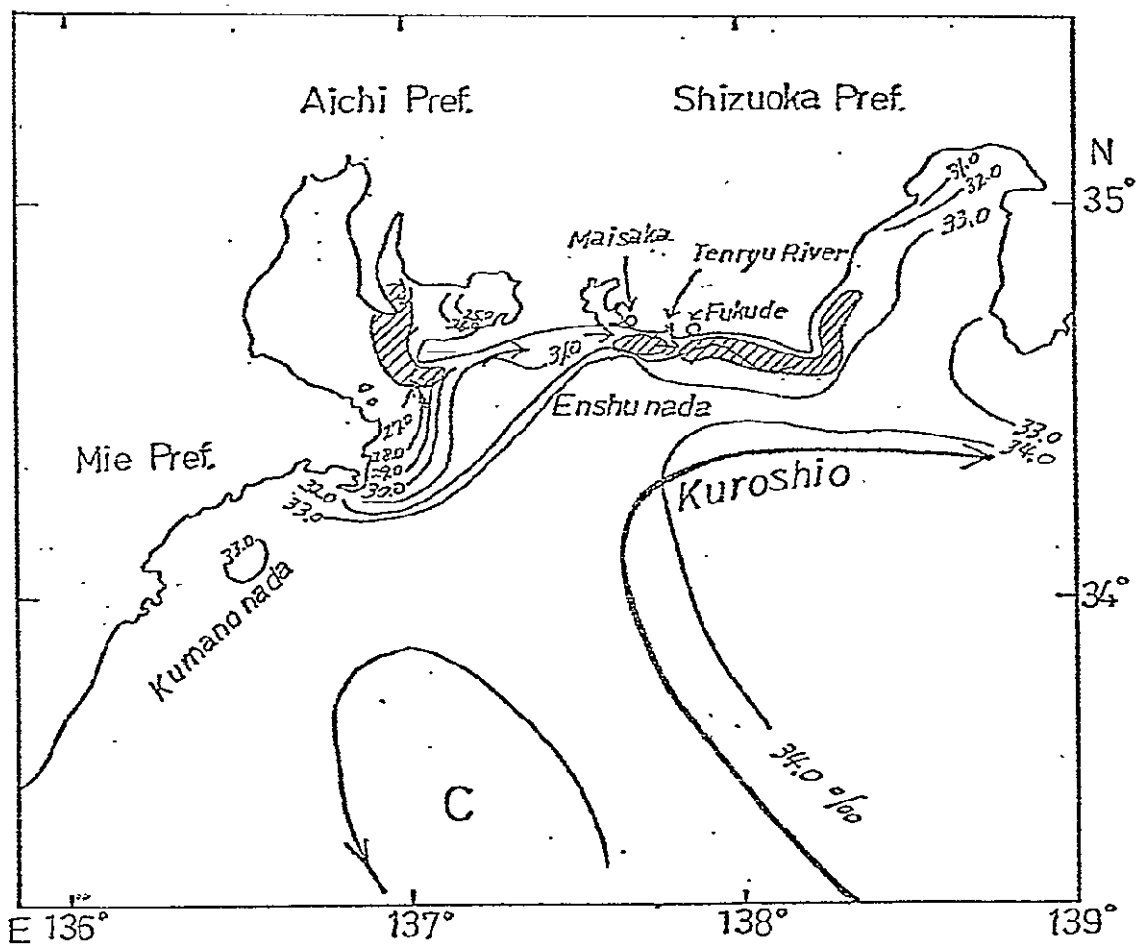

Figure 3. Locations of *shirasu* fishing grounds (hatched areas) and surface isohalines in September 1975.

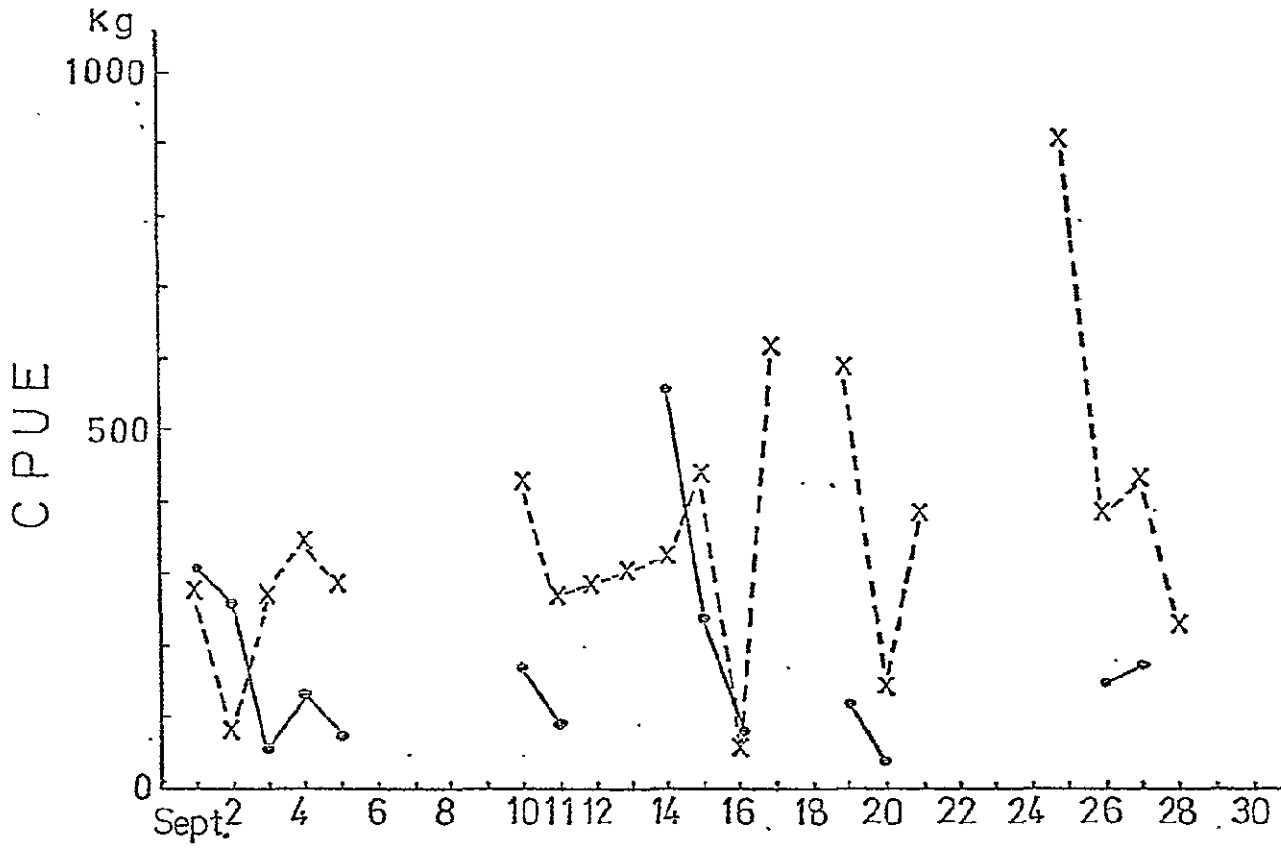

Figure 4. Daily landing of *shirasu* at Maisaka (solid line) and Fukude (broken line) in Shizuoka Prefecture, September 1975.
CPUE: Catch per day per boat.

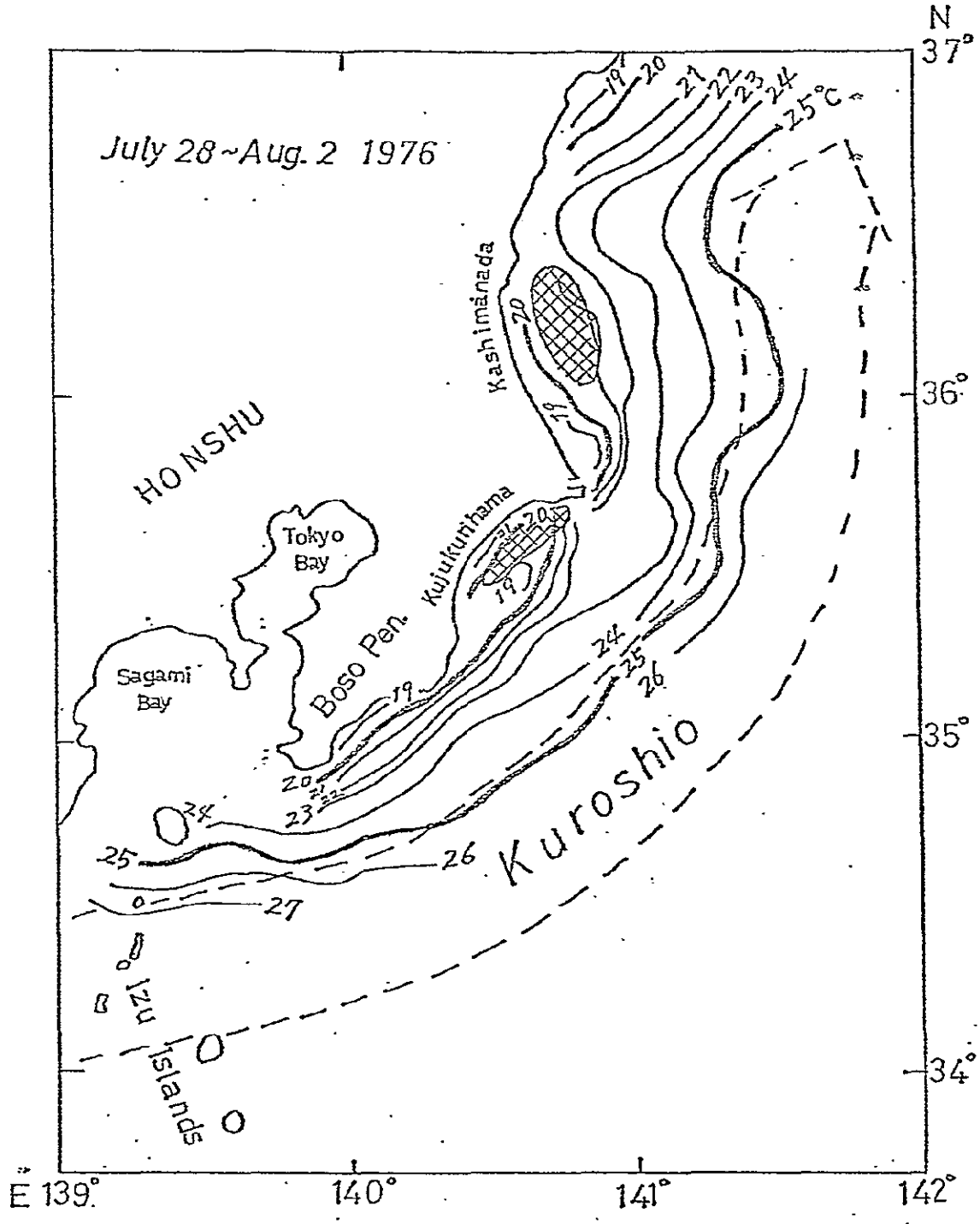

Figure 5: Locations of sardine fishing area (hatched areas) and surface isotherms during July 28 – August 2, 1976 (After data of Chiba Prefectural Fisheries Experimental Station)

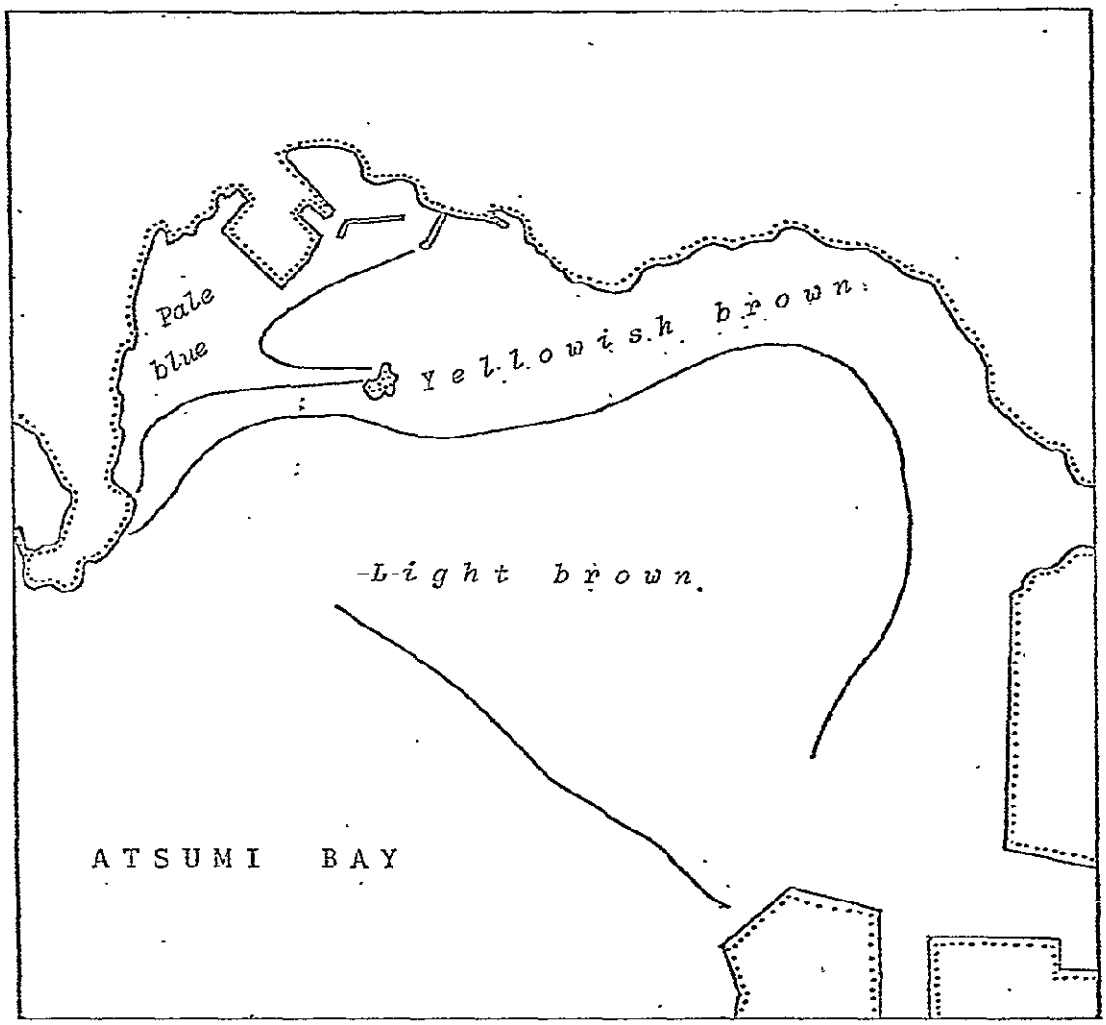

Figure 6. Water color distribution in the innermost part of Atsumi Bay in September 9 , 1976
(After Aichi Prefectural Fisheries Experimental Station)

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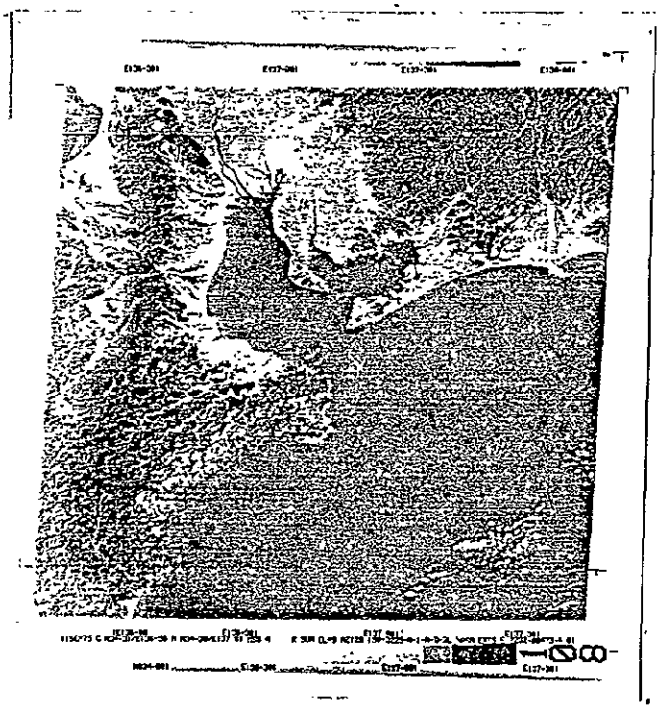

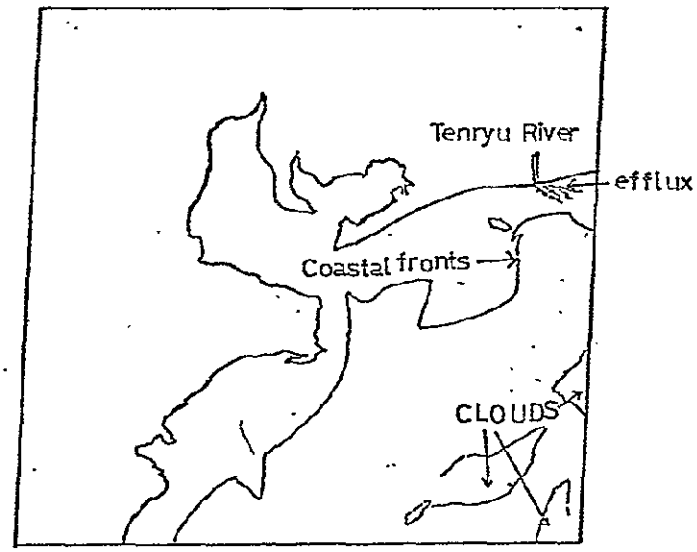

PLATE I. MSS-4 imagery of Ise Bay – Enshu-nada

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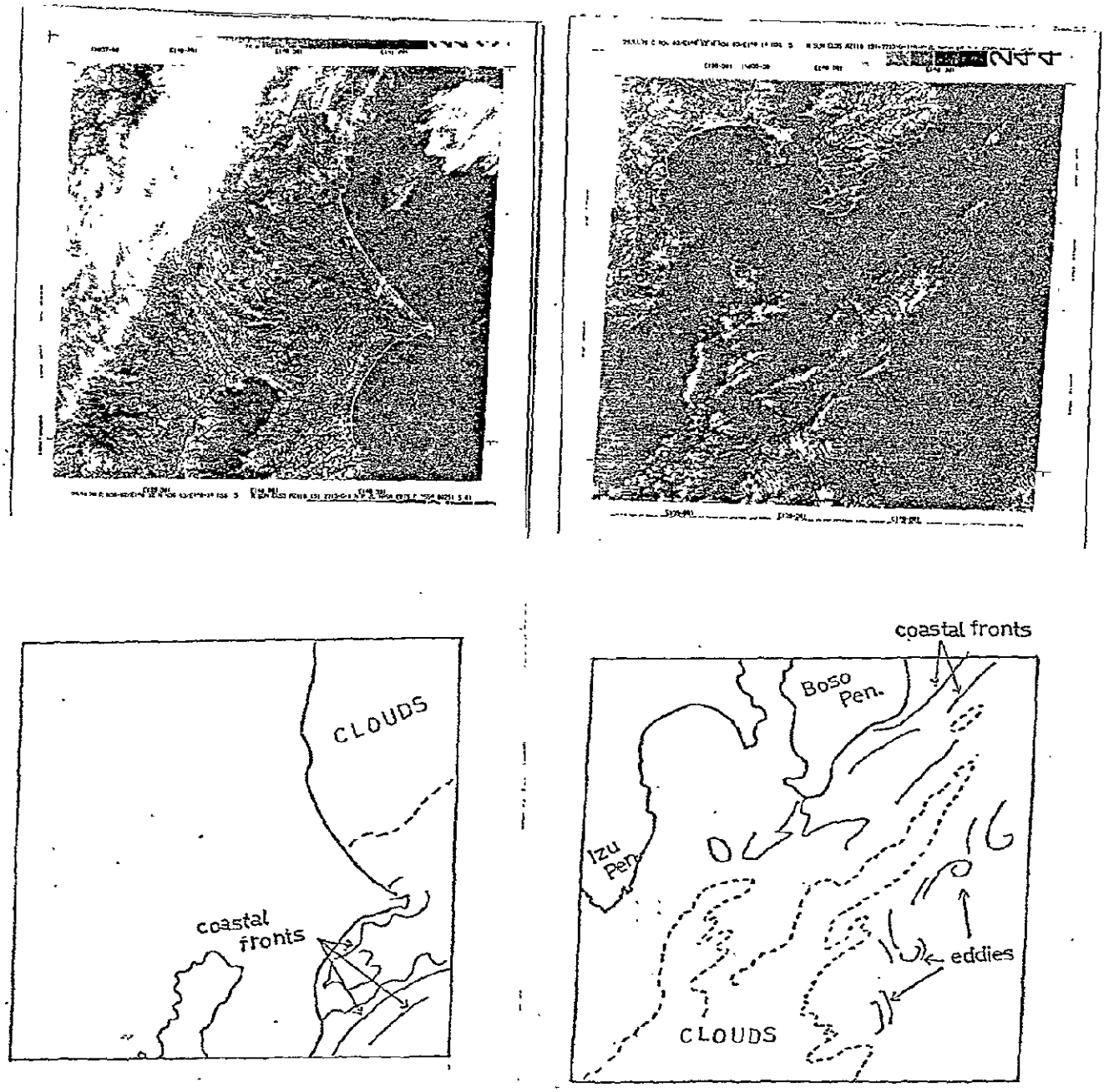

PLATE II. MSS-5 imageries of Kanto District (left) and Izu Islands (right)

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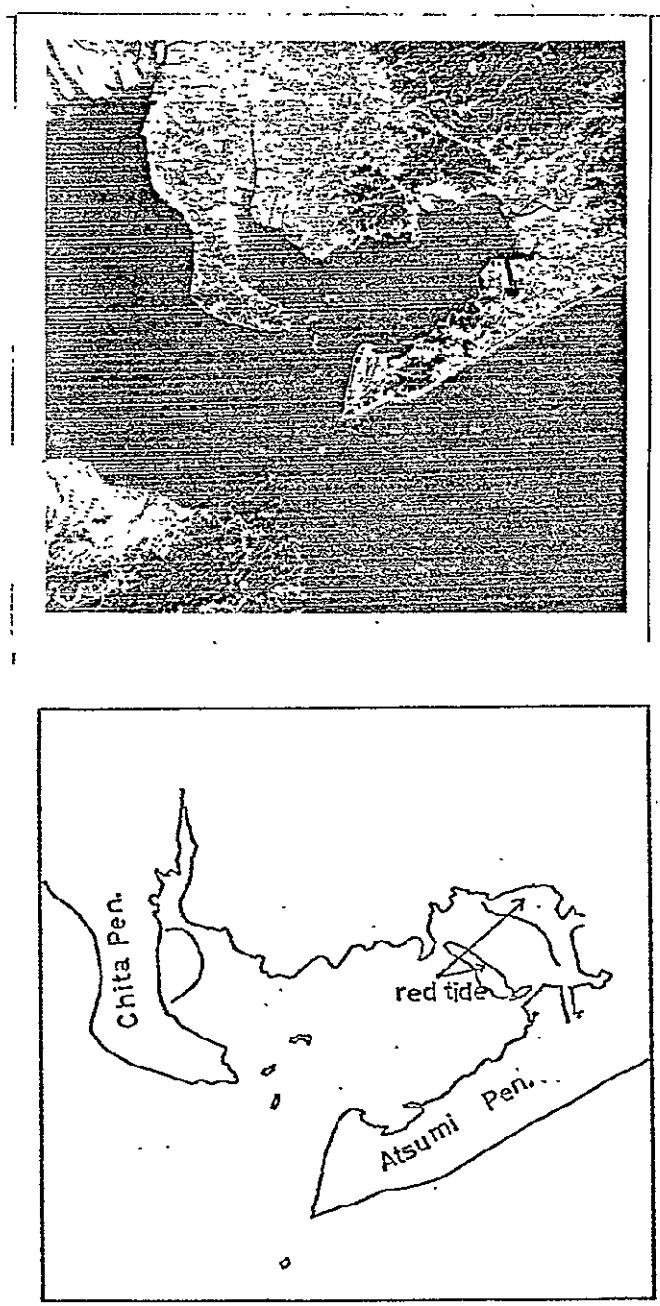

PLATE III. Enlarged part of Plate I showing red-tide area in the innermost part of Atsumi Bay